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NPS-CKM Testbed: Architecture and Cognitive Aspects

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NPS CKM Testbed Objectives

- Provide plug-and-play testbed environment for CKM collaborative technology products integration in network-centric tactical and C2 experiments

  (2005-NEO, 2006-MIO, 2007-HLD/HLS)
- Enable integration of CKM products with government or commercially developed collaborative tools that can improve team self-synchronization and situational understanding
- Provide support for situational understanding and cognitive aspects monitoring processes across the testbed nodes and operation centers

NPS CKM Testbed Architecture

- Tactical Self-Forming Network with Reach Back Command Center (NPS-SOCOM TNT Testbed): Maritime Interdiction (jointly with LLNL) and UAV-based ISR Network
- Operational teams (cells): SOCOM units (USASOC, Navy SEALs, AFSOC), Coast Guard Units, Coalition SOF units (Sweden, Austria, Singapore, Australia)
- Reach back Command Centers: MSC-Coronado, NPS-Tactical, Camp Roberts-Deployable, MARAD Ship-Mobile, Overseas C2 Experimentation Centers
- Reach back Expert Teams: LLNL, Biometrics Fusion Center, Defense Threat Reduction Agency, CG Maritime Intelligence Fusion Center

NPS CKM Testbed Collaborative Tool Set

- Groove (Commercial)
- Modified EWall (MIT-NPS)
- DECODE
- Peer-to-Peer Situational Awareness Agents (NPS)
- I-DecS (PSE)
- SOFT Tool (SOF Units Mission Panning-SOCOM)
- Cursor-on-Target (Collaboration with UAV operators-MITRE)

NPS CKM Testbed Services

- Frequency of Experimentation: Every Quarter
- Human resources: 8-20 people class or/and 6-12 thesis students
- Operational integration: NPS-TNT MIO Experiments, OFT Wolf Pac Experiments
- Access: Operation Centers, unmanned aerial and ground vehicles, MARAD Ships, SOF small boats
- Reach back extension: VPN services to the new sites

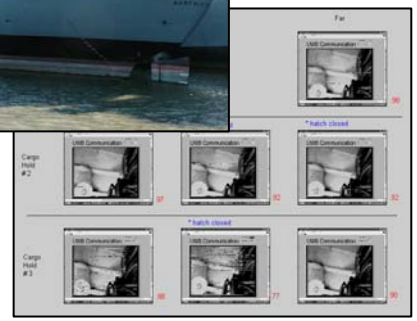
CKM Testbed Networking Characteristics

- Plug-and-play wide area adaptive network with global reach back capabilities and rapidly deployable self-forming wireless clusters (including student network operation services 24/7)
- Local networking clusters: ship-to-shore, ship-to-ship, ship-UAV-ship, ship-USV-ship, ship-AUV, sensor mesh mobile networks
- Operational focus: Boarding Parties support, MIO connectivity and collaboration for radiation awareness, biometrics identification, non-proliferation machinery parts search , and explosive materials detection on the board of the target vessel during the boarding party search phase

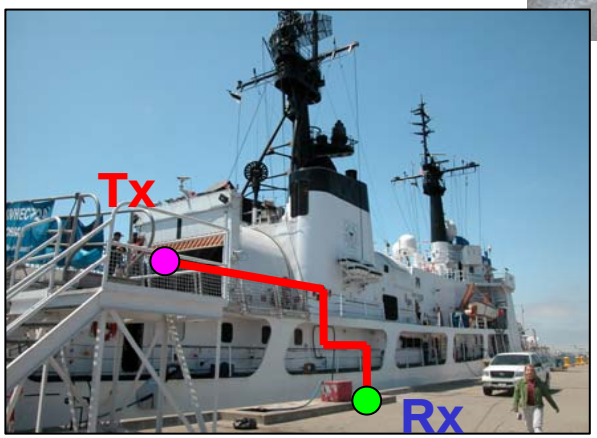
Background: Prior NPS-LLNL experiments focused sending data and video in real time within a boarded ship to external networks

Feb 05 TNT: 802.11B affected by radar

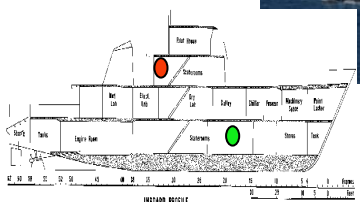
May, August 05 TNT UWB comms



Suisun Bay: UWB able to transmit between holds of a container ship with holds closed!



UWB on board USCGC Munro (multi-deck, no radar)

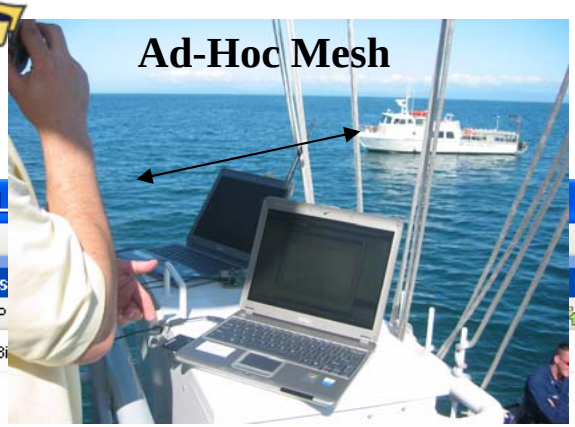


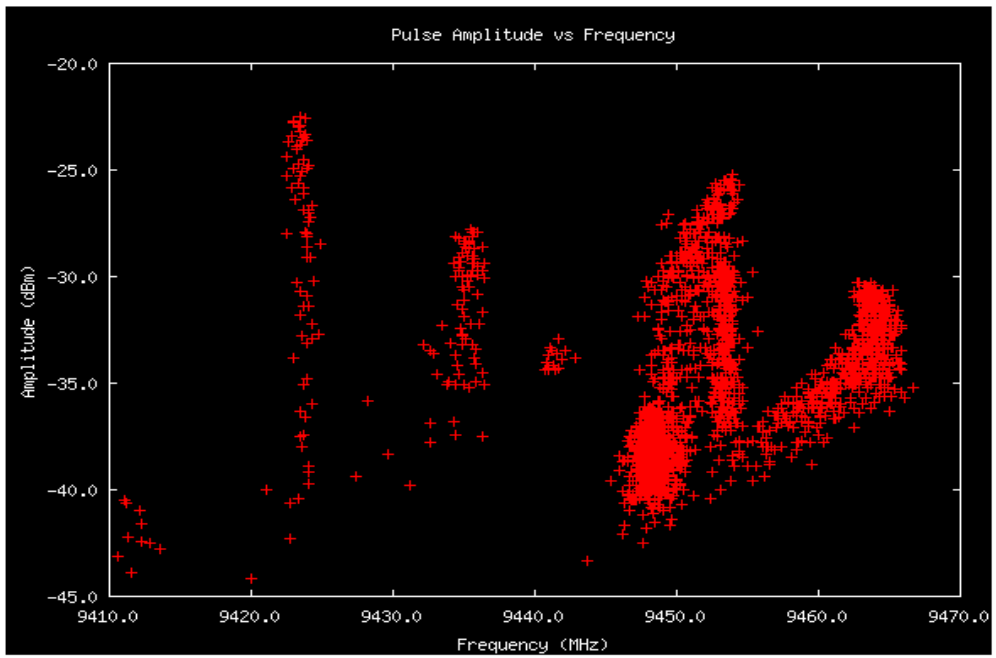
Collected system performance data on operational ship (Point Sur) UWB WORKED in difficult high multipath environment

Polar Star – Planned experiment w/ USCG R&D Center

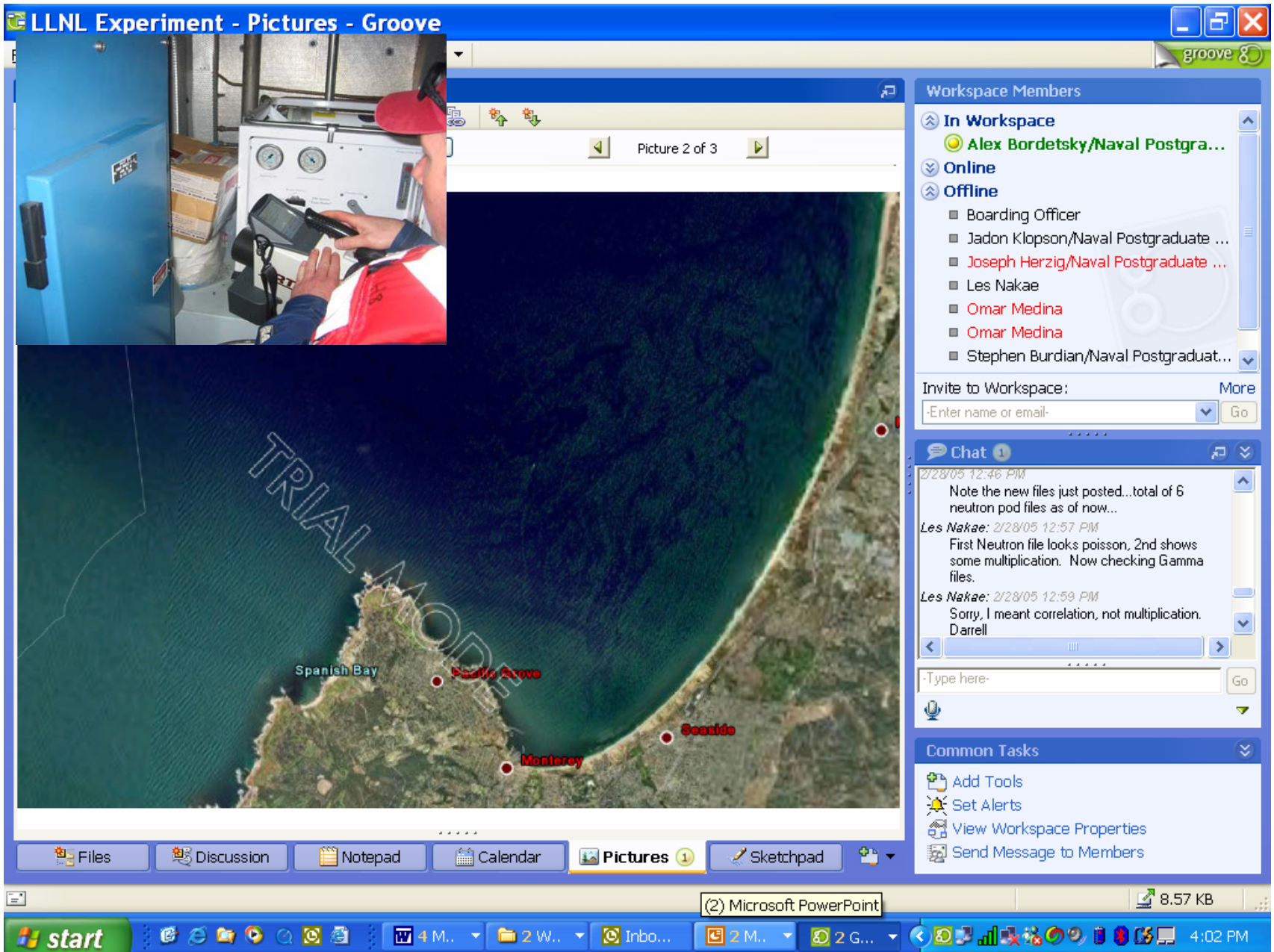
Target Ship Enters Monterey Bay; Collaboration with TACSAT for Ship ID

Ship-to-Ship





Radiation Awareness: Collaboration with LLNL for Radiation Analysis via the TNT



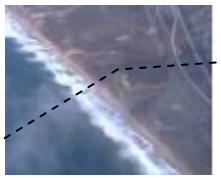
TNT Testbed: unique plug-and-play facilities with 24/7 wireless network connectivity, operated by student NOC crews

NPS CIRPAS
UAVs and Manned
Aircraft

Local Access
Ft. Ord MOUT

Access to
Ft. Hunter
Liggett

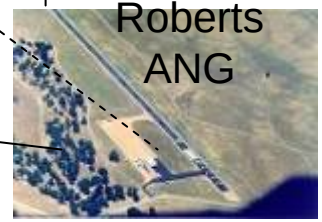
U.S. Army
SATCOM



NPS Beach
Lab

NPS

MOU with
Camp
Roberts
ANG



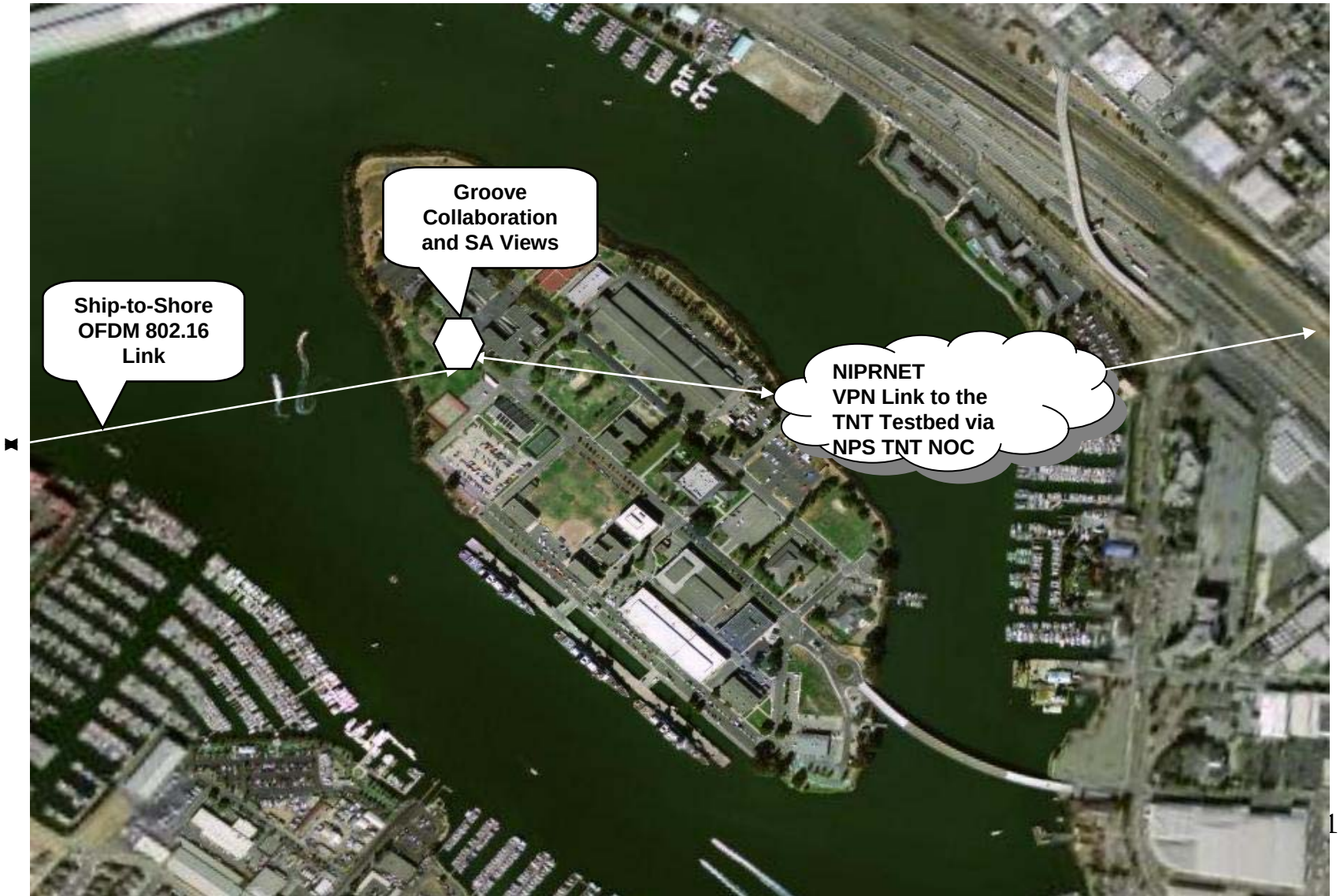
~100 mi

Monterey Bay

NPS McMillan Field
UAV Flight Facility

Unlimited Use of
Restricted Air Space

Boarding Party Network Integration : Getting connected to the remote C2 and Expert sites via the VPN to NPS TNT NOC



Ship-to-Shore long-haul wireless link back to Coast Guard Command Center and MIFC

Self-Forming Boarding Party network to Target ship: Ship-to-Ship Collaborative Environment

Testbed Networking Extension Underway in 2006

- SF Bay Area: Alameda Island MARAD Fleet-MIFC and Suisun Bay
- State of New Jersey: Health Emergency Network (with Dr. Dan Boger and Dr. Dan Dolk)
- Canada: C2 Experimentation Center, Port Security Facilities in BC (with Dr. Kendall Wheaton, CDE)
- Austria: Galileo Testbed in the Bavarian Alps (with Dr. Ulrich Hoffmann, Salzburg Research)
- Sweden: Port and Border Security Police Facilities in Southern Sweden (with Dr. Henrik Friman, SNDC)
- Singapore and Australia (exploring connectivity options)

Testbed Networking Extension Underway in 2006 (jointly with SOCOM and LLNL)

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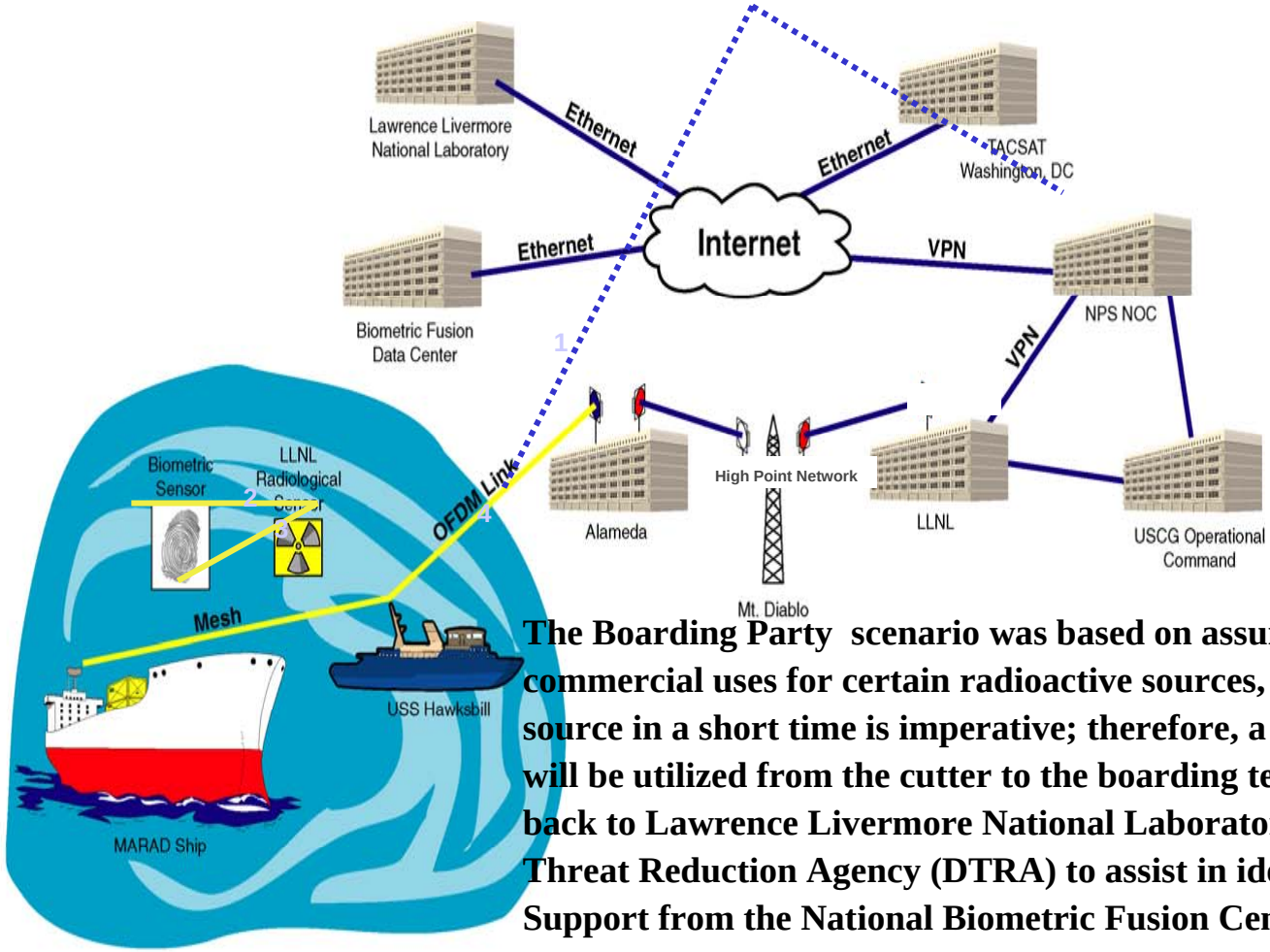
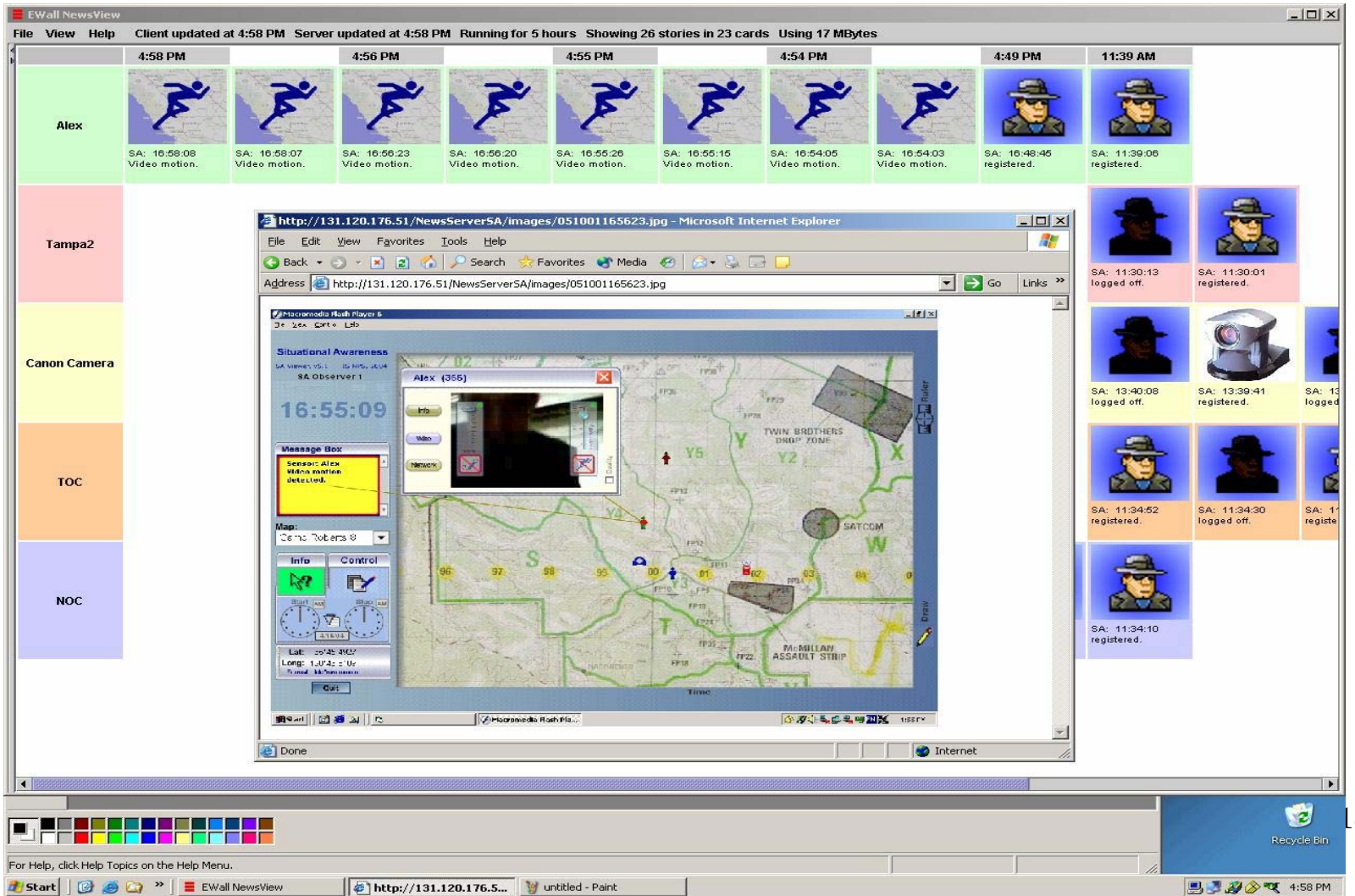
Testbed Reach Back Collaborative



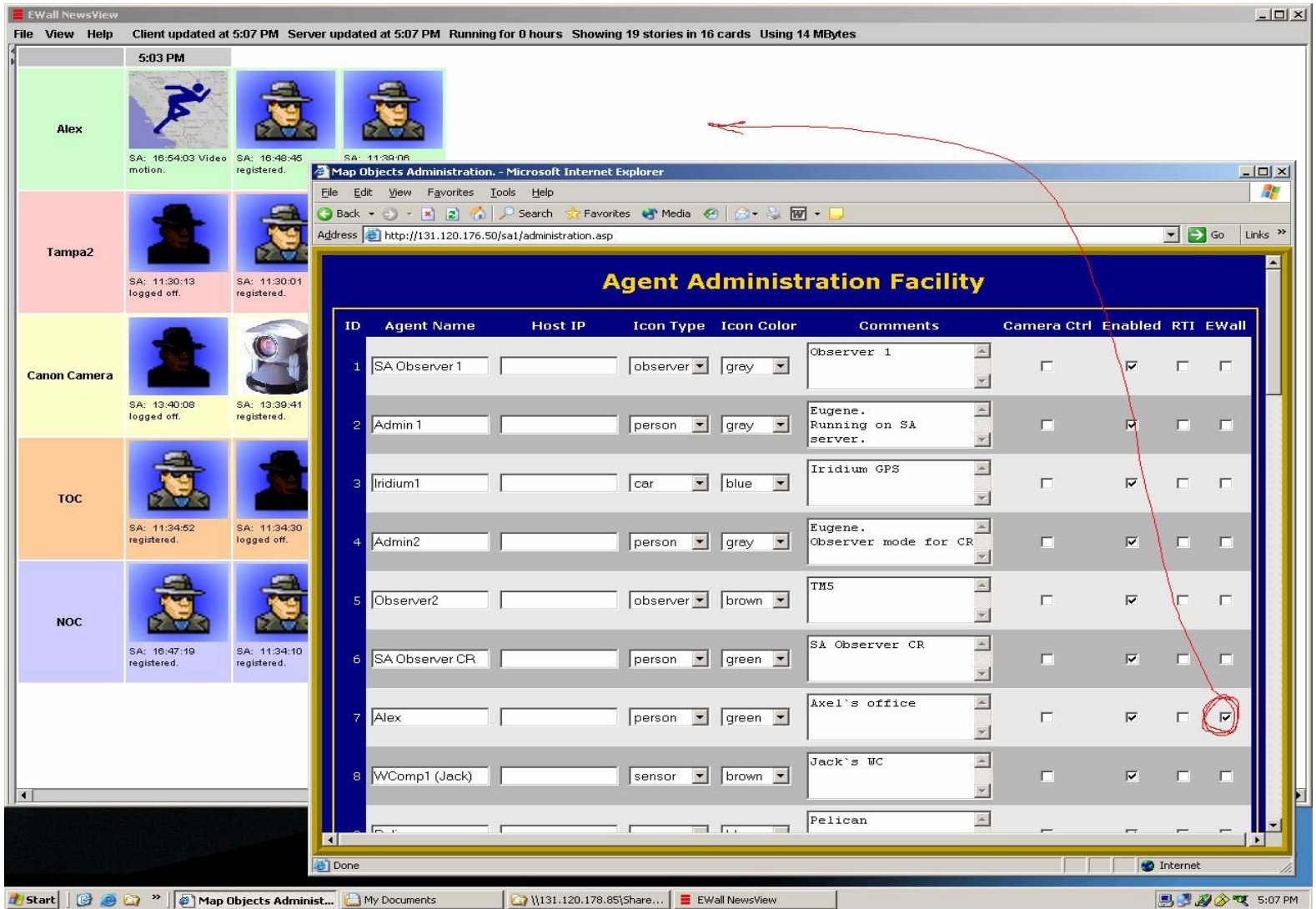
The Boarding Party scenario was based on assumption that there are numerous commercial uses for certain radioactive sources, positive identification of the source in a short time is imperative; therefore, a network extension capability will be utilized from the cutter to the boarding team. That network will reach back to Lawrence Livermore National Laboratory (LLNL) and the Defense Threat Reduction Agency (DTRA) to assist in identification of suspect cargo. Support from the National Biometric Fusion Center must be used to quickly and accurately discriminate between actual vessel crewmembers and non-crew suspect persons. Having received a situational briefing, the boarding team moves to conduct the board of the suspect vessel and establish a collaborative network to assist in the search phase.

EWall Integration with Situational Awareness Agents

Agent-EWall integration creates network-centric memory mechanism for developing shared understanding of SA events



Data Base Integration of Sensor-DM Agents and EWall Servers



Next Steps in NPS-CKM Testbed Collaborative Tools Integration:

-EWall Integration with Groove
-EWall Integration with Cursor-on-Target Systems: Collaboration with UAV Operators,
-PSE I-DecS Integration in MIO Experiment Planning Process

CoT for UAV Coordination

- Information needed to coordinate multiple UAVs is one example of CoT message usage
- All CoT-aware programs can read essential features out of any CoT message
  - System-specific information goes in Details field

What:	***Tasking***
When:	***Task Validity Period***
Where:	***Search Location***
Details:	***Target Description***

What:	***Tasking Status***
When:	***Now***
Where:	***Search Location***
Details:	***Target Description***

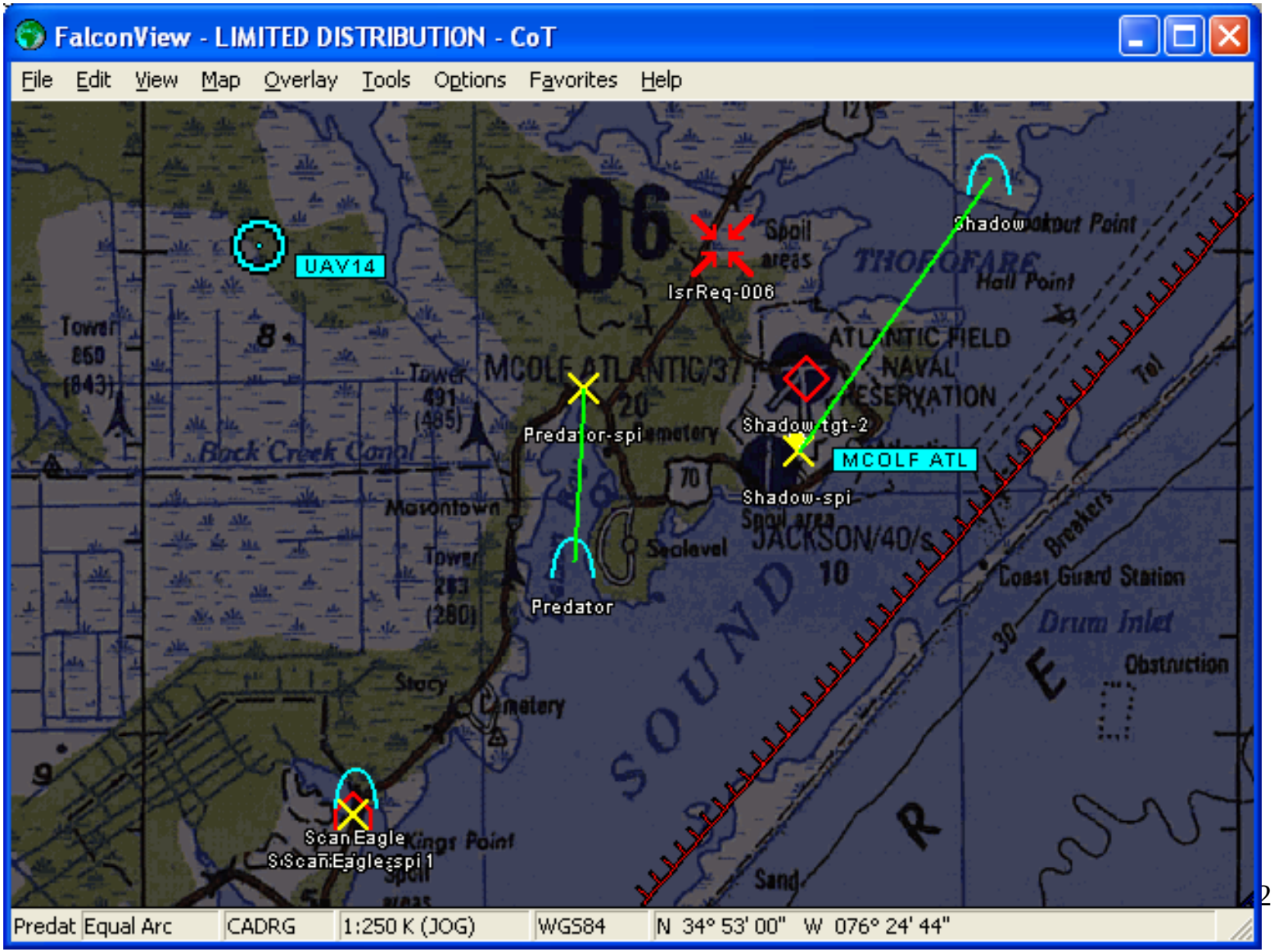
What:	***UAV Position Report***
When:	***Now***
Where:	***Current UAV PPLI***
Details:	***UAV ID***

What:	***SPOI Position Report***
When:	***Now***
Where:	***Current UAV SPOI***
Details:	***UAV ID***

What:	***Target Nomination***
When:	***Now***
Where:	***Current UAV SPOI***
Details:	***Target Type, UAV ID***

What:	***Chat***
When:	***Now***
Where:	***Everywhere***
Details:	***Message Text***

Multiple Source SA Display



PSE-NPS I-DecS Integration: Boarding Party Mission Planning Collaboration

- Purpose:
- To assess the utility of I-DecS in a planning exercise of Naval Officers.
- Description:
- A LOE experiment will be conducted with the PhD Large Scale Systems and Experiment Design Class. The subjects will use I-DecS to plan an upcoming experiment using the TNT-MIO scenario.
- Schedule:
- The experiment will take place in early February before the February 22 experiment start date.
- Participant Material: TNT Scenario, Quick reference guide for I-DecS
- Data Collection Material: I-DecS Printouts , Post Experiment Survey

What's Next in Testbed Operational Capabilities

- Collaborative environment for Rapid Research Response Based MIO Operations (R3-based Operations). Enabling 5-8 hours feasibility/constraint analysis collaborative experiment to support the ongoing operation
- An immediate access to the network of radiation detection, biometric fusion, non-proliferation machinery, and intelligence experts
- Enabling remote teams of observers from the theater locations joining the NPS CKM testbed

Monitoring Collaborative Work and Situational Understanding Development

NPS-CKM Implementation in TNT-06-2 Maritime Interdiction Experiment:

November 22-23, San Francisco Bay

Testbed Collaborative Work Support and Monitoring Capabilities:

MIO Experiment with the MARAD Fleet in Alameda Island, CA, November 22-23

TNT 06-1 MIO Collaborative Technology Study Objectives

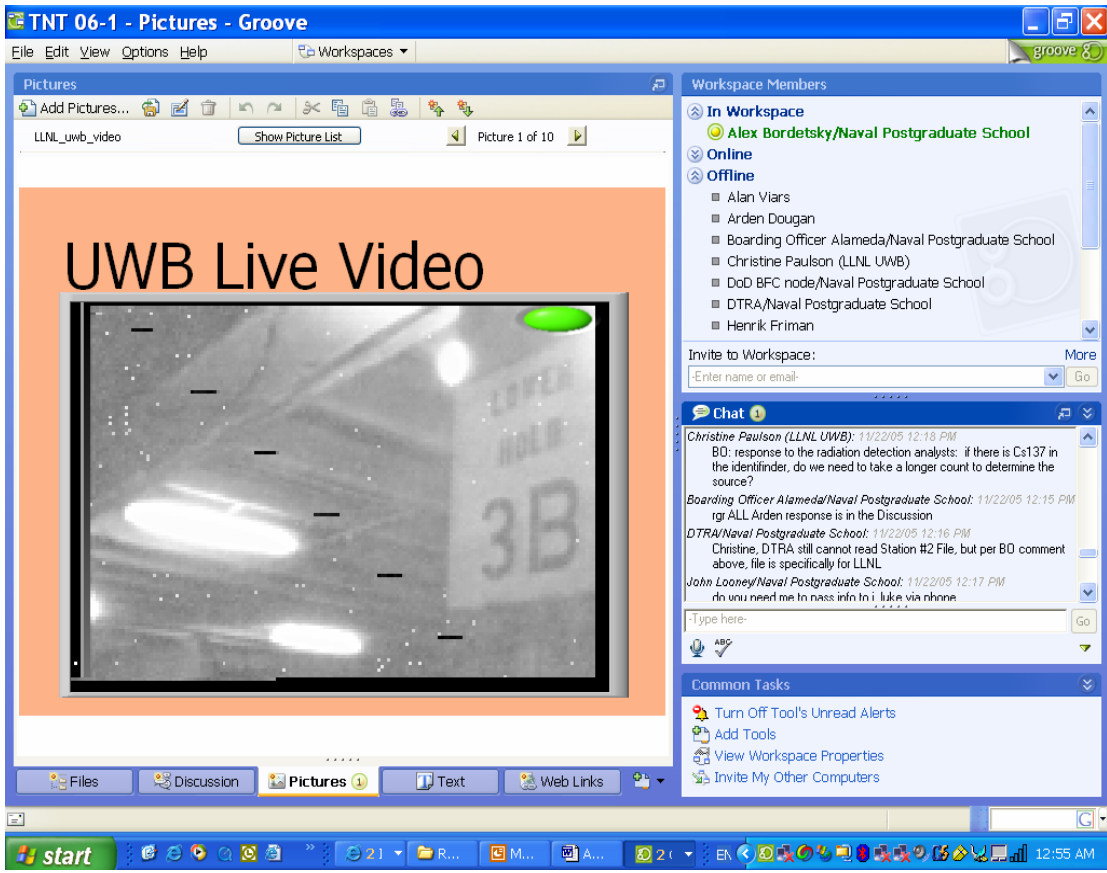
- Enable Connectivity and Collaboration for Radiation Awareness, Biometrics Fusion in Maritime Interdiction Operations
- Explore the Challenges of MIO Collaborative Network Performance in the Environment of Big Cargo Ships
- Collaborative Performance with the Remote Teams of Experts
  - Latency of syncronization with all sites (out band coordination)
  - Frequency of messaging and ACK (by NOCWO log)
  - Reliability and quality of asset video and image sharing (remote site observation
- Explore Cognitive Problems in Boarding Party Situational Understanding development

Collaboration on Stretching OFDM Man-Pack Boarding Party Network to Target Ship (15min)

Collaboration on Target Ship Crew Biometrics Identification Between Boarding Party and Biometrics Fusion Center (West Virginia) (4 min)

Ultra-Wideband Link Based Collaboration with Radiation Detection Officers Operating Below the Deck

UWB Video Monitoring of Boarding Party Radiation Detection Performance from Under the Deck Areas (Groove-based Collaboration)

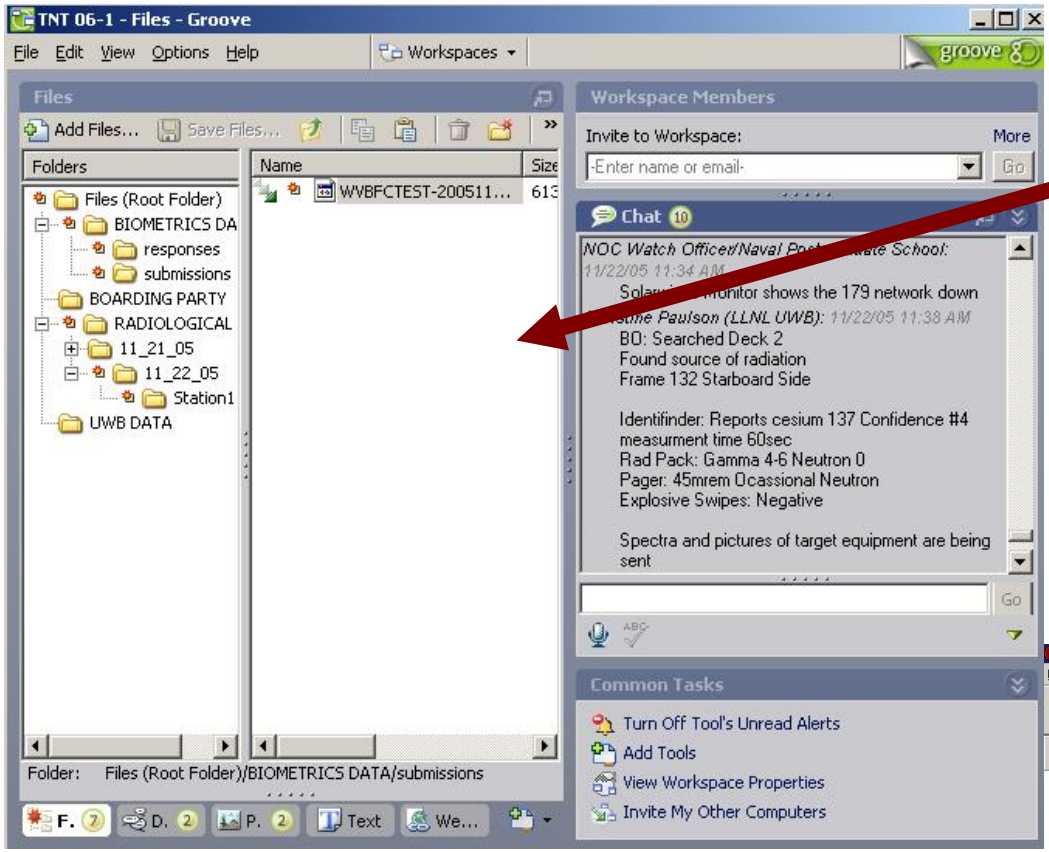


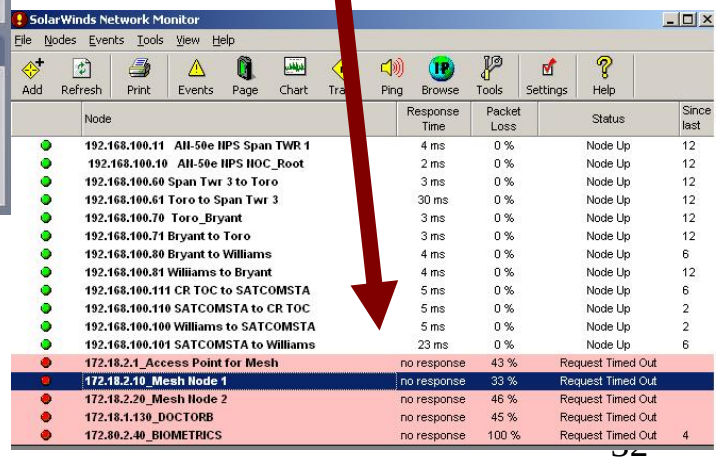
Performance Management & Collaboration Environment

GROOVE:
Common Operation Picture

NETWORK MONITOR:

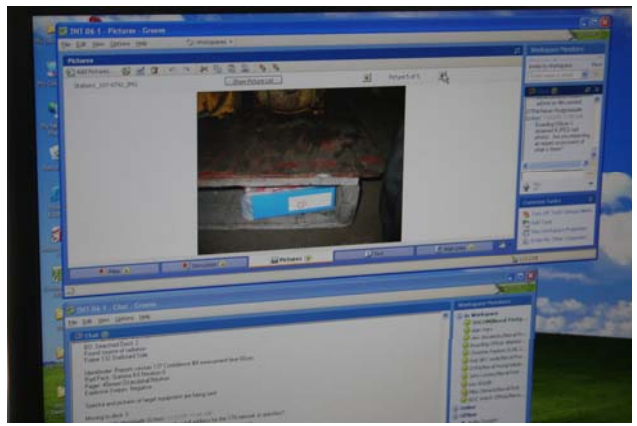
Nodes shown down



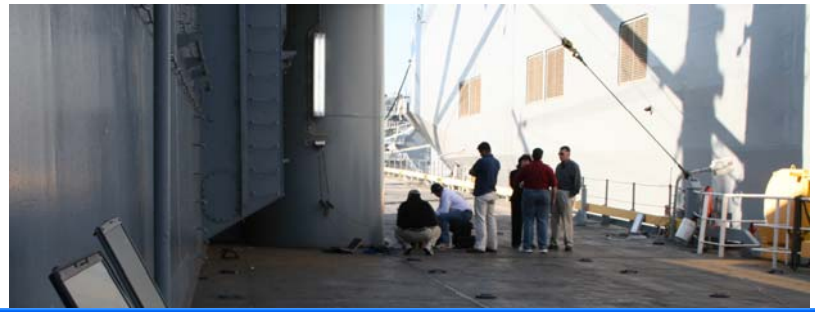


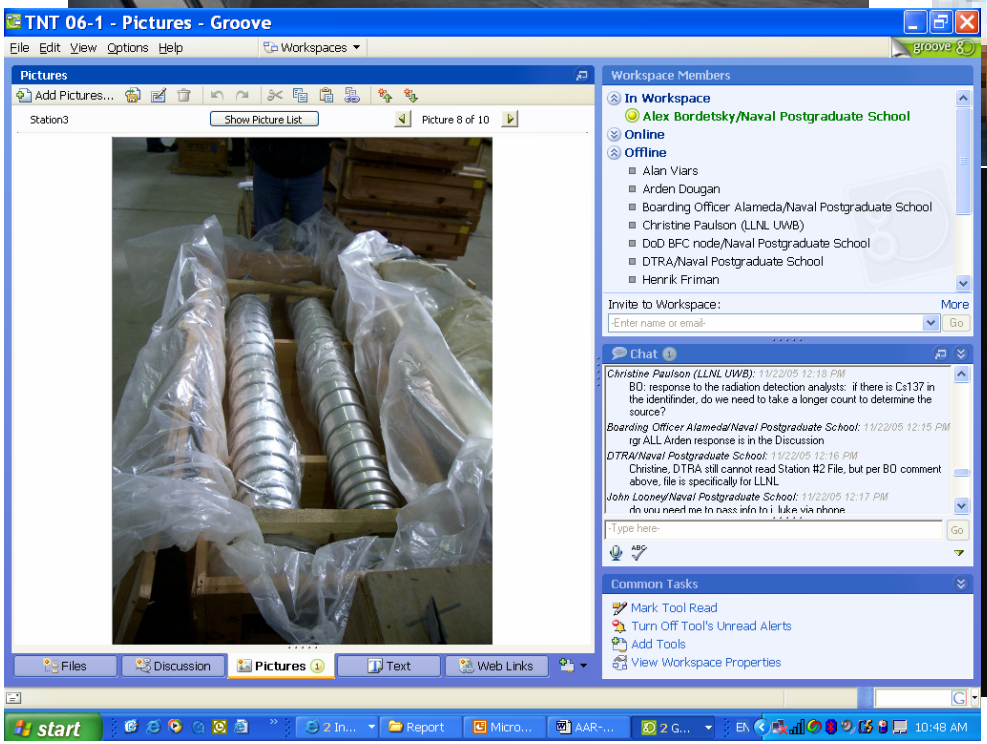
Video Monitoring of Geographically Distributed Collaborative C2 and Data Fusion

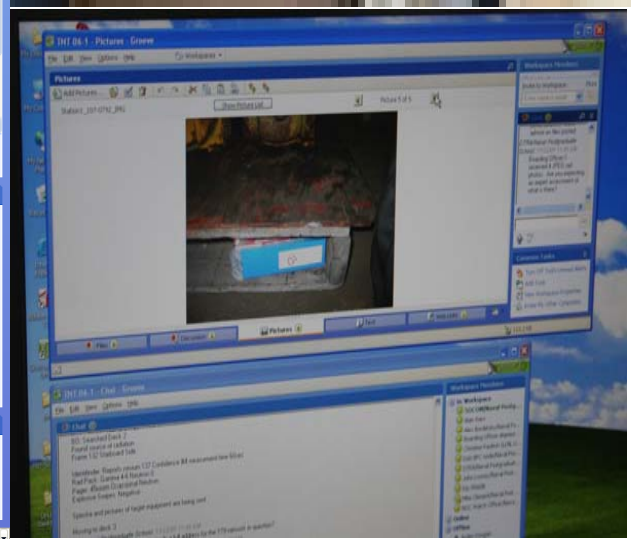
Distributed team of Experts and Command Officers: Mobile Command Post (C2 input), DTRA (machinery smuggling), LLNL (radiation detection), SOCOM (ops advice)



Boarding Party Self-Synchronization and Situational Assessment with TOC and DTRA Experts







NPS TESTBED FOR TEAM COLLABORATION MODEL VALIDATION AND KNOWLEDGE TOOL APPLICATION

- **Dual Goals:**

1) **Test applicability of using a wireless network for data sharing to facilitate reach back to experts for radiation source analysis and biometric data analysis.**
2) **Understand and improve the effectiveness of team decision-making in complex, data-rich situations by validating the model of team collaboration.**

Model of Team Collaboration

- **Emphasizes cognitive aspects of the collaboration process and includes the major cognitive processes that underlie this type of communication:**
  - **(1) individual knowledge building**
  - **(2) knowledge interoperability**
  - **(3) team shared understanding and**
  - **(4) team consensus (Warner, Letsky, & Cowen, 2004).**

- **Validate that these processes exist and how they contribute to team performance through verbal protocol analysis coding of team communications.**
- **Learn how the EWALL can support collaborative problem solving within the scenarios/ tasks employed in the GIGA CODE Lab.**

Scenario: Maritime Interdiction Operation (MIO)

- Board ship to search for contraband cargo and possible terrorist suspects
  - Intel indicates vessel may carry radioactive material – positive ID of source in short time is imperative
  - Crew members may be terrorist suspects posing as crewmen
  - Boarding team boards suspect vessel and establishes collaborative network and begins their respective inspections and data collection processes
- Boarding Party Team Members:
  - Boarding Officer – Coast Guard, laptop with Groove collaboration tool
  - Lawrence Livermore National Labs – portable radiation detection devices
    - Reach back to LLNL to analyze data to determine presence of radiation
  - Defense Threat Reduction Agency (DTRA) – collect video imagery
    - Reach back to check against databases at remote facility
  - Biometrics Fusion Center – Biometrics measurements
    - Fingerprints checked against databases at remote facility
  - Special Operations Command (SOCOM) – simulated by LCDR at NPS
    - Leadership provides guidance on handling of hazardous material
  - Network Operations Center – NPS
    - Monitoring/ recording wireless network performance

TEAM COLLABORATION MODEL VALIDATION AND KNOWLEDGE TOOL APPLICATION

Problem Area Characteristics

- Collaborative Situation Parameters
  - Time pressure
  - Information/ knowledge uncertainty
  - Dynamic information
  - Large amount of knowledge
- Team Type
  - Asynchronous
  - Distributed
  - Culturally diverse
  - Heterogeneous knowledge
  - Unique roles
  - Command structure
  - Rotating team members
- Operational Tasks
  - Team Decision Making, Course of Action (COA) Selection
  - Develop Shared Understanding

-- Team Data Processing

Tasks

- Finalize scenario to include collaborative problem solving (Oct 05)
- Finalize data collection plan (Oct 05)
- Collect and analyze data without EWALL capability (Nov 05 – Feb 06)
- Report findings wrt macro-cognitive processes and team performance (Mar 06)
- Collect and analyze data with EWALL capability (Feb 06)
- Report findings wrt macro-cognitive processes and team performance (May 06)
- Analyze comparative data (Jul 06)
- Final report on relevance of macro cognitive processes and impact of EWALL on team performance (Sep 06)

Technical Approach

- **Code team communications using cognitive process definitions developed by Norm Warner.**
- **Focus on knowledge building and team consensus for:**
  - **Finding and verifying radioactive material: Is it raw material for a nuclear weapon?**
  - **Finding and verifying centrifuge parts: Can the equipment process radioactive material into a nuclear weapon?**

Collaborative Workspace

- **Bring expert services into the boarding party team's tool set**
  - **Support ability to quickly assess situation and quickly interpret the data**
- **Facilitated voice and text communications between all members of virtual boarding party and physical boarding party**
  - **Remote sites able to receive/ open posted files <2 min to begin analysis**
  - **Expert services provided at LLNL quickly determined need for additional data capture of longer length and different angles of approach**
    - **Request transmitted by text message and taken for action**
  - **Radiation source spectrum captures were made of suspect containers that were detected to have a radiation signature presence**
  - **Analysis led Boarding Officer to recommend that the vessel be quarantined for further inspection**
- **Biometric team took digital prints of crew to compare to known criminal prints and latent prints from terrorist and crime scenes.**
- **Great potential for producing communications that reflect complex human decisionmaking problem**

MIO Scenario Coding Example

Team Shared Understanding Development

MIO Team Communications

DTRA Cesium 137 can be used to make an RDD. If there are no explosives, then it is not configured as a weapon yet. Recommend material be confiscated.

BO Rgr will confiscate.

BO Mark material for confiscation.

BO Make sure you handle carefully. Cs-137 is an external gamma hazard.

BO Rgr. Will take precautions.

SOCOM Does CG ship have proper storage area for mat'l confiscated?

SOCOM Search team will report size of material and its current containment condition; then make recommendations.

Cognitive Process Coding

MCsa: develop, rationalize and visualize solution alternatives = using data to justify a solution

MCitk: individual task knowledge dev't.= individual TM clarifying data

MCkio: knowledge interoperability =TMs exchanging *knowledge* among each other.

MCitk: individual task knowledge dev't = individual TM clarifying data, asking for clarification.

MetCcu: team integration of individual knowledge for common understanding = one or more TMs combine individual pieces of knowledge to achieve common understanding

MIO Scenario Coding Example

Knowledge Interoperability Development

MIO Team Communications

BO Negative for explosives Station 2

LLNL finally rec'd RAD data from station 2

SOCOM …Will need to resolve RAD containment hazard if it exists.

DTRA …If you have plutonium, you need to confiscate. It's an alpha hazard, but still must be handled carefully.

BO Rgr

DTRA BTW, if plutonium is in solid metal form, your team can handle safely with rubber gloves and a dental face mask, depending on how much is there.

BO Talking to search team to see if this is within their capabilities or if we will need outside assets.

LLNL Hazard is probably minimal, can isolate and confiscate.

Cognitive Process Coding

KIO: knowledge interoperability development = TMs exchanging *knowledge* among each other.

KIO: "

MetCCU: team integration of knowledge for common understanding = all TMs combine individual pieces of knowledge to achieve a common understanding.

MacKIO: knowledge interoperability development =TMs exchanging *knowledge* among each other.